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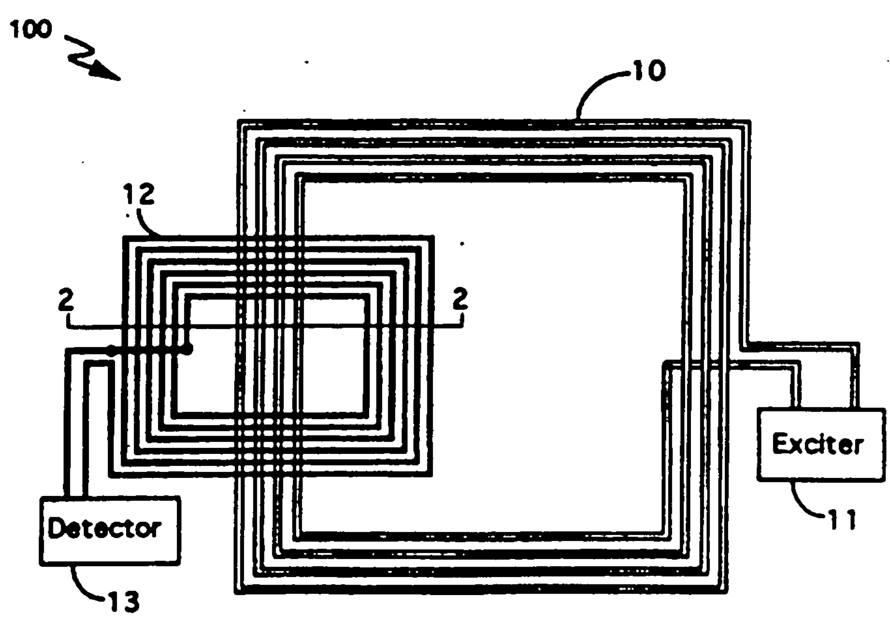

(57) Abstract

A combination of elements is disclosed for use in a security access circuit (100). A first antenna (10) is embedded on a printed circuit board and a second antenna (12) is embedded on the same printed circuit board. The second antenna (12) is embedded at a position relative to the first antenna (10) selected to reduce interference between the first antenna (10) and the second antenna (12).

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SECURITY ACCESS CIRCUIT USING EMBEDDED ANTENNAS

DISCLOSURE

Field of the Invention

The present invention relates to a security access circuit using embedded antennas.

Background of the Invention

Security systems are important for controlling personnel access to specific locations. Many modern security systems place a card reader at a secure entrance to read an access card. A person seeking access places the card in close proximity to the card reader which reads the card and then grants access, if appropriate, to the location.

One type of access card reader has a transmit antenna and a receive antenna. These antennas are wire coils soldered to a printed circuit board. The reader transmit antenna transmits a radio frequency (RF) signal to the card. The card contains a receiving antenna and a capacitor to convert the reader transmitted RF signal into power for the card circuitry. Once the capacitor is charged, the card then transmits a security code to the reader.

The reader receives the security code on the reader receive antenna. The reader then decodes and verifies the security code and grants access. Unless the reader verifies the security code, it will not grant access.

Because the card reader both transmits and receives RF waves, the transmit and receive antennas must be carefully located with respect to one another to reduce interference.

Interference causes corruption of the security code transmission from the card and can prevent the card reader from correctly interpreting the security code. One cause of interference is mutual inductance between the antennas.

A known approach to reduce the interference between a transmit antenna and receive antenna is to employ a technician to manually position the antennas during manufacture of the reader printed circuit board. The technician induces a current in the transmit antenna and observes interference in the receive antenna on an oscilloscope. The technician moves the receive antenna around on the printed circuit board to find a location of least interference. He then fixes the receive antenna to the printed circuit board by tacking portions of it with glue and soldering it down. This approach is time consuming and requires future tuning if the coils are deformed or disturbed during shipment or operation.

Summary of the Invention

The present invention provides an apparatus and method for overcoming the problems of interference between a card reader transmit antenna and receive antenna.

A combination of elements is disclosed for use in a security access circuit. A first antenna is embedded on a printed circuit board and a second antenna also is embedded on the printed circuit board rather than simply being tacked to it. The second antenna is embedded at a position relative to the first antenna selected to reduce interference between the first antenna and the second antenna.

The placement of the antennas is controlled by the printed circuit board manufacturing process. Thus, no adjustment by a technician is required. Further, the antennas are straightforward to manufacture and deploy. Also, since the antennas are formed during the manufacture of the printed circuit board, the antennas are mechanically stable during the life of the product. As a result, the

reliability of the circuit is increased and the cost decreased.

Brief Description of the Figures

With reference to the accompanying figures:

Figure 1 depicts an antenna layout employing the invention;

Figure 2 depicts a cross-section of Figure 1 along the section 2-2;

Figure 3 depicts a single-turn antenna layout employing the invention, and illustrates the electro-magnetic fields present in Figure 1;

Figure 4 depicts a cross-section of Figure 3 along the section 4-4 and illustrates the electro-magnetic fields present in Figure 1;

Figure 5 depicts a second antenna layout employing the invention; and

Figure 6 depicts a cross-section of Figure 5 along the section 6-6.

Detailed Description of a Preferred Embodiment

The following description is provided to satisfy the patent statutes. Those skilled in the art will appreciate that various changes and modifications can be made to the preferred embodiment while remaining within the scope of the present invention.

Figures 1 and 2 depict a security access circuit 100 employing the invention. Figure 1 shows two antenna coils as a transmit antenna 10 and a receive antenna 12. These antennas are metal traces embedded on a printed circuit board 16 and each one has a plurality of turns. The receive antenna 12 is positioned on the printed circuit board 16 to reduce interference from the transmit coil 10 and other related circuitry. As shown in Figure 1, this position is roughly half inside and half outside the transmit antenna 10. An exciter 11 is connected to the transmit antenna 10 and a detector 13 is connected to the receive antenna 12.

The metal traces that constitute the antennas 10, 12 are embedded on a printed circuit board 16 as shown in Figure 2. The printed circuit board 16 of Figure 2 is a multi-layer printed circuit board that has traces embedded both on the outside layers and on the inside layers. These traces can be embedded on the top of the printed circuit board 16 as shown by traces 10, or can be embedded on one of the printed circuit board layers and encapsulated in the printed circuit board, as shown by several of the traces that constitute the receive antenna 12. Traces on different layers are connected by vias where necessary.

While the printed circuit board 16 is usually made from epoxy glass, any substance can be used for the invention. The important feature is that the printed circuit board 16 be transparent to electro-magnetic (EM) waves.

For purposes of simplification, the operation of the invention is explained with reference to Figures 3 and 4, which show a single turn transmit antenna 10 and a single turn receive antenna 12. The exciter 11 first generates a current flowing clockwise, for example, in the transmit antenna 10. A reference arrow and lower-case letter i shows this direction. This current creates magnetic flux 18a-c extending through the transmit antenna 10, as shown in Figure 4. The magnetic flux 18a-c creates a field that extends outward from the center of transmit antenna 10 and bends around the antenna 10 to form a continuous path.

Figure 3 shows the amount of magnetic flux extending through the transmit antenna 10 and receive antenna 12, as a result of the exciter created flux 18a-c. The crosses (X) represent the tail of an arrow and indicate the flux travelling into the page. The bullets (◉) represent the tip of an arrow and indicate the flux travelling out of the page.

Figures 3 and 4 show that the transmit antenna 10 and receive antenna 12 are positioned to reduce interference. The mutual inductance between the antennas is shown by the effect of the transmit antenna flux 18a-c on the receive

antenna 12. Note that the flux 18a-b is flowing around the transmit antenna 10, and that an equal amount of the flux 18a-b is entering and departing the receive antenna 12. Hence, the flux 18a-b causes no net influence on the receive antenna 12. The flux 18c extends through the transmit antenna 10 and does not enter or depart the receive antenna 12. Hence, the flux 18c has no net effect on the receive antenna 12. This placement results in low interference between transmit antenna 10 and receive antenna 12.

The position of the antennas is determined in advance using mock antenna coils. These mock antennas are individual antennas embedded on separate printed circuit board sections that represent the desired antenna configuration. That is, the mock antennas are the correct size and have the correct number of turns, but they are moveable over the surface of the target printed circuit board 16. An initial position approximation is made by placing the mock receive antenna half-inside and half-outside of the mock transmit antenna.

Since additional circuitry used in the card reader - such as the exciter 11 and detector 13 - has an overall influence on the transmitted and received EM waves, its effect is determined by experiment, and the antennas are positioned to minimize its effect. The additional circuitry is turned on, and the mock antennas are moved around on the printed circuit board. Once the positions having the least interference are determined, the antenna positions are selected. These selected positions are used for manufacturing the printed circuit boards with the antennas embedded thereon.

In one implementation of the invention a 6-layer printed circuit board is used. A 9-turn transmit coil is constructed with 4 turns on the component layer and 5 turns on the solder layer. The coils are rectangular in shape with the outside dimensions of 3 inches by 3.5 inches. The trace width is .08 inch with .02 inch separation between turns. A 120-turn receive coil is constructed with 30 turns on each

of the 4 inner layers. the coils are rectangular with the outside dimensions of 2 inches by 3 inches. The trace width is .01 inch with .01 inch separation between turns. The two coils overlap to reduce the interference to below 40dB. In operation, the exciter applies a sinusoidal wave to the transmit antenna having 50 volts peak to peak and a frequency of 140 KHz.

In a second implementation a 6-layer printed circuit board is used. A 1-turn transmit coil is constructed with 1 trace on the component layer and 1 trace on the solder layer. The coils on different layers are connected to one another by via feed-through holes at 2 inch intervals. The coils are rectangular in shape with the outside dimensions of 10 inches by 18 inches. The trace width is 1 inch. A 160-turn receive coil is constructed with 40 turns on each of the 4 inner layers. The coils are rectangular with the outside dimensions of 3 inches by 4 inches. The trace width is .01 inch with .01 inch separation between turns. The two coils overlap to reduce the interference below 40dB. In operation, the exciter applies a sinusoidal wave to the transmit antenna having 50 volts peak to peak and a frequency of 140 KHz.

When a person seeks access to an area secured by an access card reader using the invention, the person places an access card within the transmit antenna flux 18a-c. The access card is influenced by the transmit EM waves. The card gathers energy from the emanating magnetic flux and stores the energy in a capacitor. Once the capacitor is charged, the card transmits a security code to the reader. The security code is in the form of EM waves that flow through the receive antenna 12. This causes a current to flow in the receive antenna 12 and be detected by the detector 13. The detector 13 verifies the security code and permits the security circuit to grant access to the person, if appropriate.

Several advantages arise from the embedded antenna invention. For one, the reduced interference between the

transmit antenna 10 and receive antenna 12 increases the chance that the receive antenna 12 will pick up the security access transmission from the card and that the detector [illegible] will properly detect the security code.

Another advantage is that the antennas are straightforward to manufacture and deploy. The antennas are embedded on the printed circuit board during manufacture and then placed in a card reader housing for operation. No adjustment by a technician is required. Also, since the antennas are formed during the manufacture of the printed circuit board, the antennas are mechanically stable during the life of the product.

Another advantage is that the invention can be made with traces that can handle a large amount of current. That is, if the traces are made large and the antenna is made large, the area that the card reader covers is large. As a result of these advantages, the performance and reliability of the card reader is increased and the cost is decreased.

Figure 5 is another embodiment 200 employing the invention. Transmit antenna 10 is designed in a circular fashion and receive antenna 12 is designed in a circular fashion. The placement of the receive antenna 12 is made to reduce the interference between the transmit antenna 10 and the receive antenna 12 as in the first embodiment. As shown in Figures 5 and 6, these antennas are a single trace with the transmit antenna embedded on one side of a printed circuit board 16 and the transmit antenna 12 embedded on the other side of the printed circuit board 16.

The configuration shown in Figures 5 and 6 is circular. The transmit antenna 10 and receive antenna 12 have low mutual inductance due to their placement according to the invention. This configuration demonstrates that the transmit and receive antennas can be constructed in any shape that permits the reduction of interference between the transmit antenna and the receive antenna.

Having disclosed a preferred embodiment and the best mode, there are a number of modifications that will be

obvious to those skilled in the art. This specification is intended to cover all embodiments within the spirit of the invention that is now claimed.

CLAIMS:

1. In a security access circuit, the combination comprising:

a first antenna embedded on a printed circuit board; and

a second antenna embedded on said printed circuit board at a position relative to said first antenna selected to reduce interference between said first antenna and said second antenna.

2. The combination of claim 1, wherein:

said second antenna is positioned relative to said first antenna to reduce mutual inductance between said first antenna and said second antenna to below 40dB.

3. The combination of claim 1, wherein:

said printed circuit board is a multi-layer printed circuit board;

said first antenna has a plurality of turns spanning a plurality of layers of said printed circuit board; and

said second antenna has a plurality of turns spanning a plurality of layers of said printed circuit board.

4. The combination of claim 1, wherein:

said printed circuit board is a 6-layer printed circuit board;

said first antenna is a 9-turn antenna; and

said second antenna is a 120-turn antenna.

5. The combination of claim 1, wherein:

said printed circuit board is a 6-layer printed circuit board;

said first antenna is a 1-turn antenna; and

said second antenna is a 160-turn antenna.

6. The combination of claim 1, further comprising:

an exciter circuit coupled to said first antenna to generate a current therethrough; and

a detector circuit coupled to said second antenna to detect current therethrough.

7. The combination of claim 6, wherein:

said current in said first antenna causes a first magnetic flux that causes an access card to react and generate a second magnetic flux extending through said second antenna; and

said second magnetic flux causes a current to flow in said second antenna, said current representing a security code, and if said detector verifies the security code, said detector issues a valid access signal.

8. The combination of claim 7, wherein:

said second magnetic flux includes a security code; and

said detector converts the current in said second antenna to a digital electrical signal to verify the security code.

9. In a security access circuit, the combination comprising:

a first antenna having a plurality of turns embedded on a multi-layer printed circuit board; and

a second antenna having a plurality of turns embedded on said printed circuit board at a position relative to said first antenna selected to reduce interference between said first antenna and said second antenna;

an exciter circuit coupled to said first antenna to generate a current therethrough, said current causes a first magnetic flux that causes an access card to react and generate a second magnetic flux extending through said second antenna; and

a detector circuit coupled to said second antenna to detect current therethrough, said current representing a security code, and if said detector verifies the security code, said detector issues a valid access signal.

10. A method of manufacturing a security access circuit, comprising the steps of:

embedding a first antenna at a first position on a printed circuit board;

embedding a second antenna on said printed circuit board at a position relative to said first antenna selected to reduce interference between said first antenna and said second antenna.

11. The method of claim 10, wherein:

said second position is located relative to said first position to reduce mutual inductance between said first antenna and said second antenna to below 40dB.

12. The method of claim 10, further comprising:

connecting said first antenna to an exciter circuit; and

connecting said second antenna to a detector circuit.

13. The method of claim 12, further comprising:

exciting a first current in said first antenna causing a first magnetic flux that causes an access card to react and generate a second magnetic flux extending through said second antenna; and

detecting a current in said second antenna that is a result of said second magnetic flux, said current representing a security code; and

issuing a valid access signal if the security code is verified.

14. The method of claim 13, wherein:

said second magnetic flux includes a security code; and

said detector converts the current in said second antenna to a digital electrical signal to verify the security code.

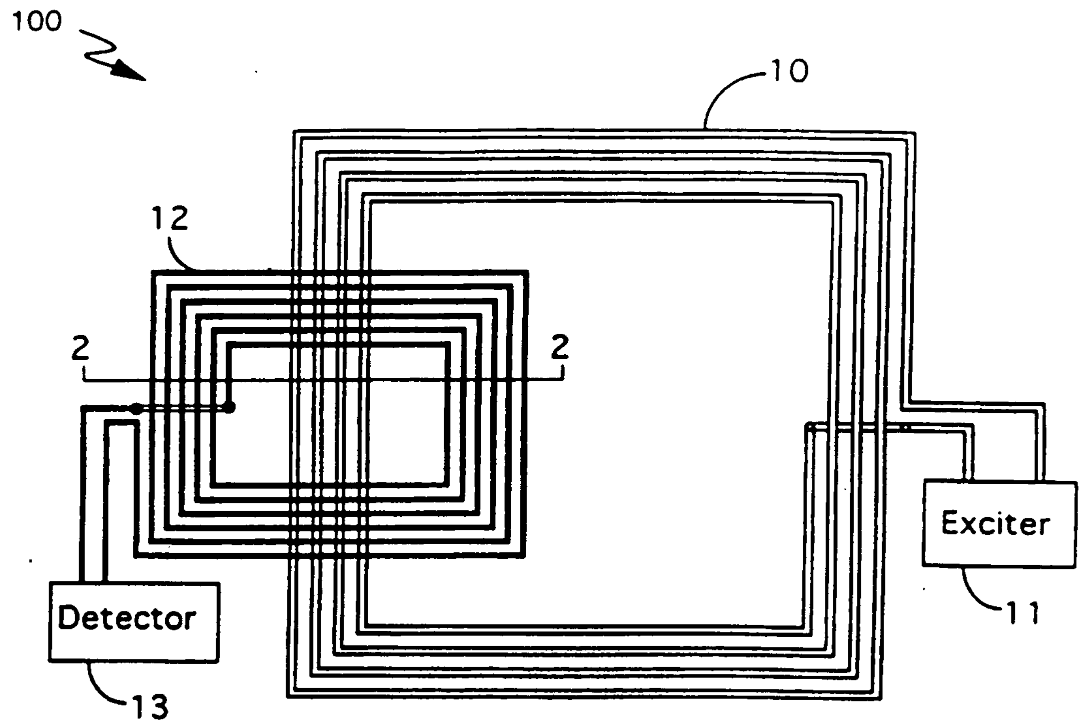

FIGURE 1

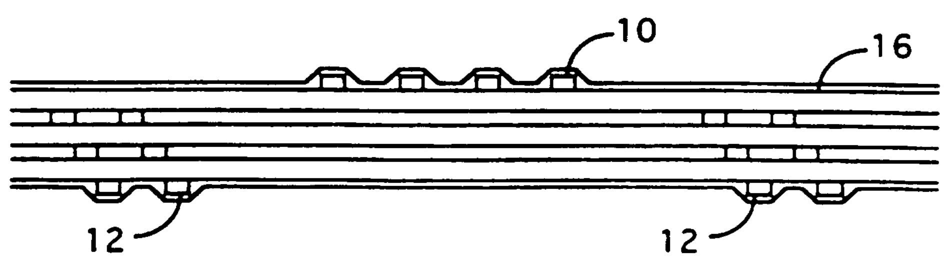

FIGURE 2

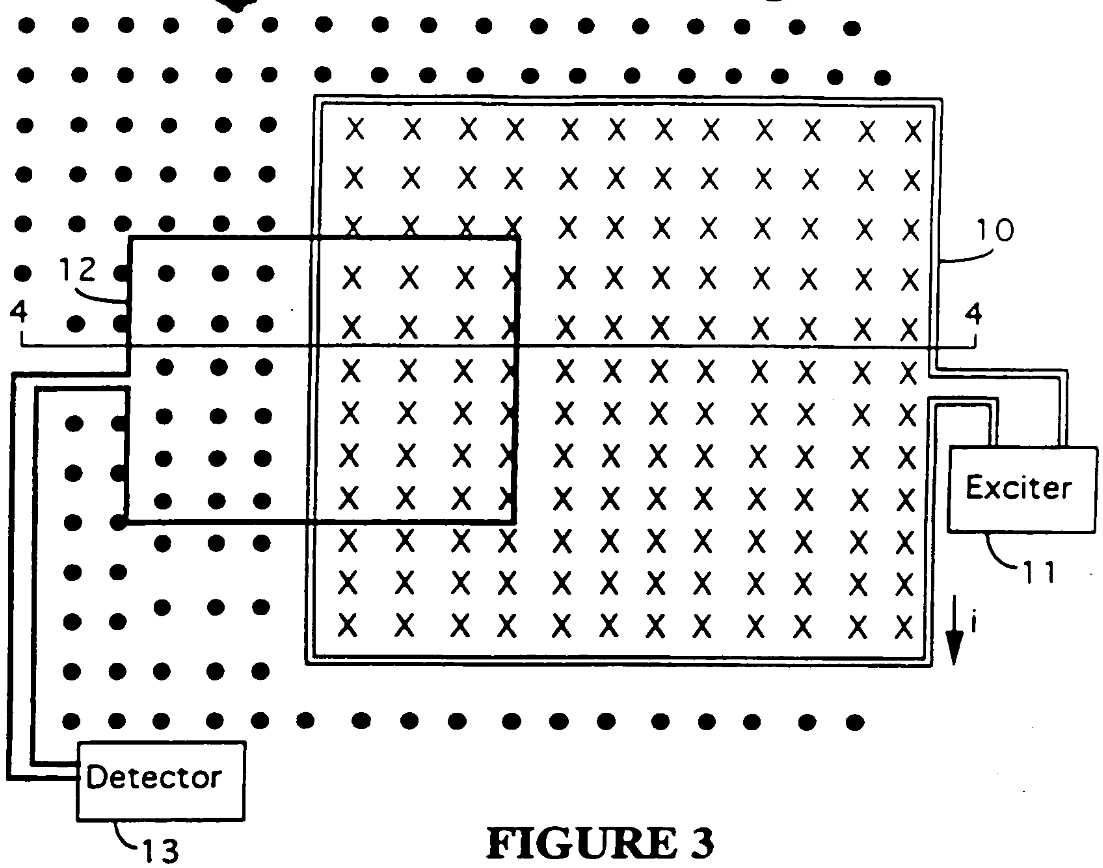

FIGURE 3

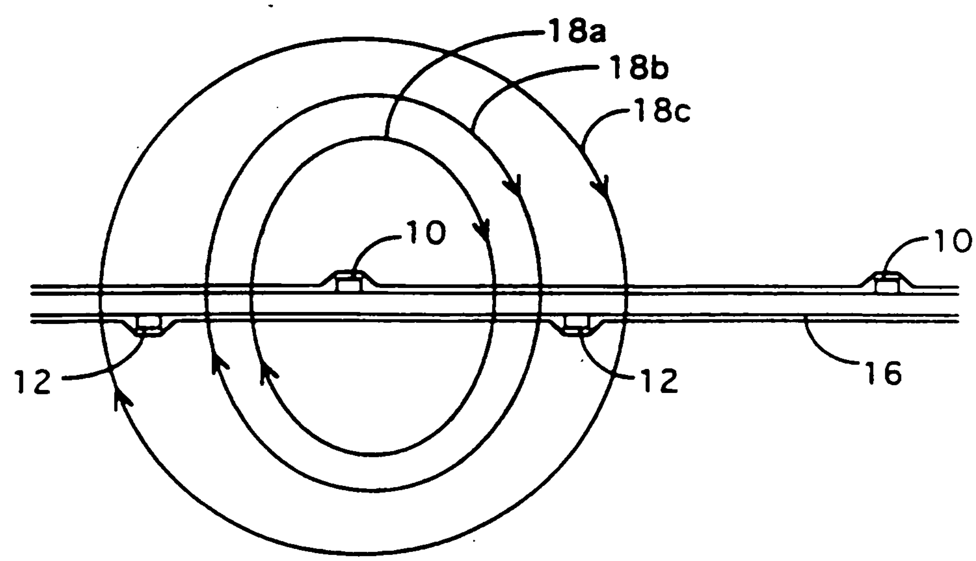

FIGURE 4

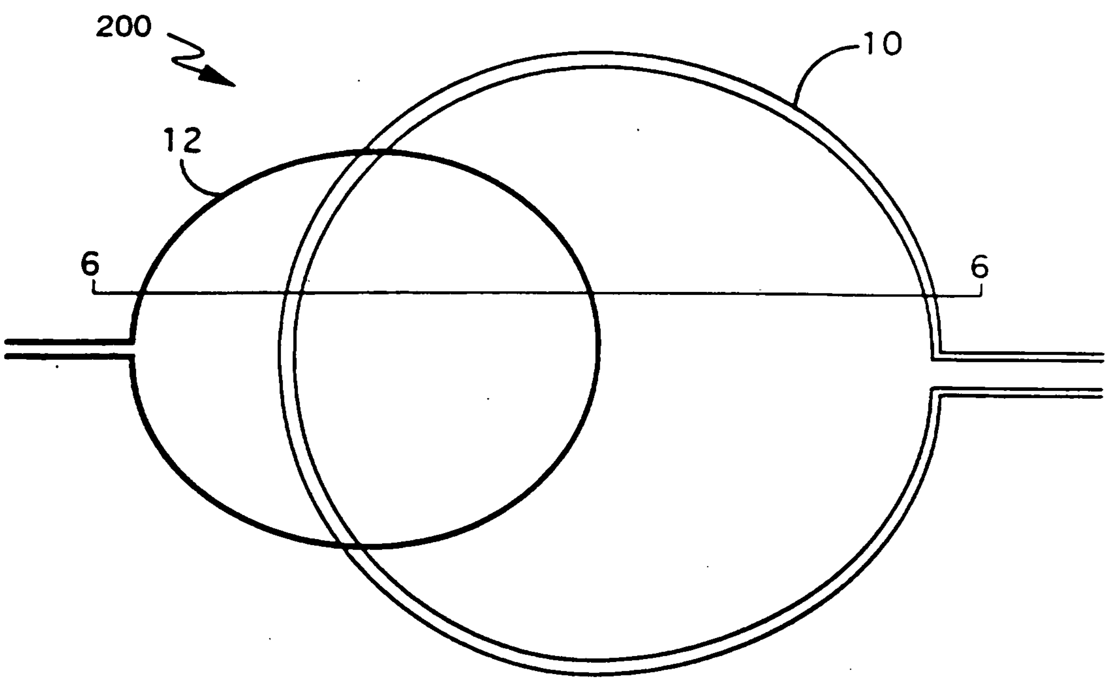

FIGURE 5

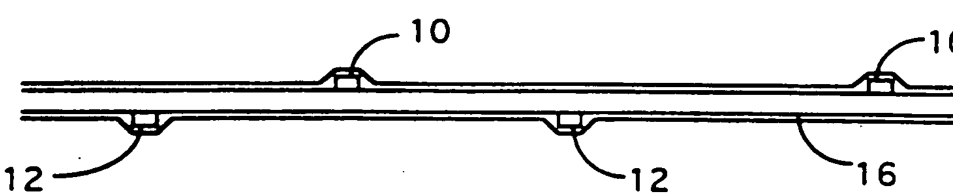

FIGURE 6

Inter nal Application No
T/US 95/08863

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G06K19/077

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP,A,0 547 563 (SIEMENS AG) 23 June 1993 see column 3, line 46 - column 5, line 28 ---	1-14
Y	WO,A,92 08209 (JURISCH REINHARD) 14 May 1992 see page 2, line 19 - page 5, line 16 see figures 1,2 ---	1-14
X	EP,A,0 079 047 (BBC BROWN BOVERI & CIE) 18 May 1983 see the whole document ---	1,2,6-8, 10-14
X	GB,A,2 239 424 (MITSUBISHI ELECTRIC CORP) 3 July 1991 see page 15, line 1 - line 24 see page 19, line 13 - page 20, line 14 see figures 5,9 --- -/--	1,2,10, 11

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 95/08863

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-0547563	23-06-93	DE-U-	9115582	17-12-92
		DE-U-	9217070	04-03-93
WO-A-9208209	14-05-92	DE-A-	4034225	30-04-92
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		US-A-	5198647	30-03-93
DE-C-3721822	10-11-88	NONE		

International Application No
PCT/US 95/08863

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
A	DE,C,37 21 822 (PHILIPS PATENTVERWALTUNG GMBH) 10 November 1988 see the whole document -----	1,9,10

1

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